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ABSTRACT

There are five categories of cable communication systems: Conventional Community Antenna Television (CATV), Pay-TV, Subscriber Response Systems, Electronic Information Handling Systems, and Two-Way Audio/Visual Systems. CATV and Pay-TV systems are designed for the one-way transmission of programs, the former providing for better quality off-the-air broadcast signals and the latter carrying special programs. The other systems are capable of two-way data transmission and offer such services as opinion polling, cashless financial transactions, computer-aided instruction, and electronic mail delivery. Economic analysis has indicated that cable systems in small markets will be economically viable supplying only CATV, but that they will have to offer Pay-TV in intermediate markets and the other two-way services in larger markets. The need to offer specialized services to widely scattered groups makes netting, via satellites or other means, highly desirable and this, in turn, requires that systems be designed in accordance with universal standards so that they will be mutually compatible. (PB)

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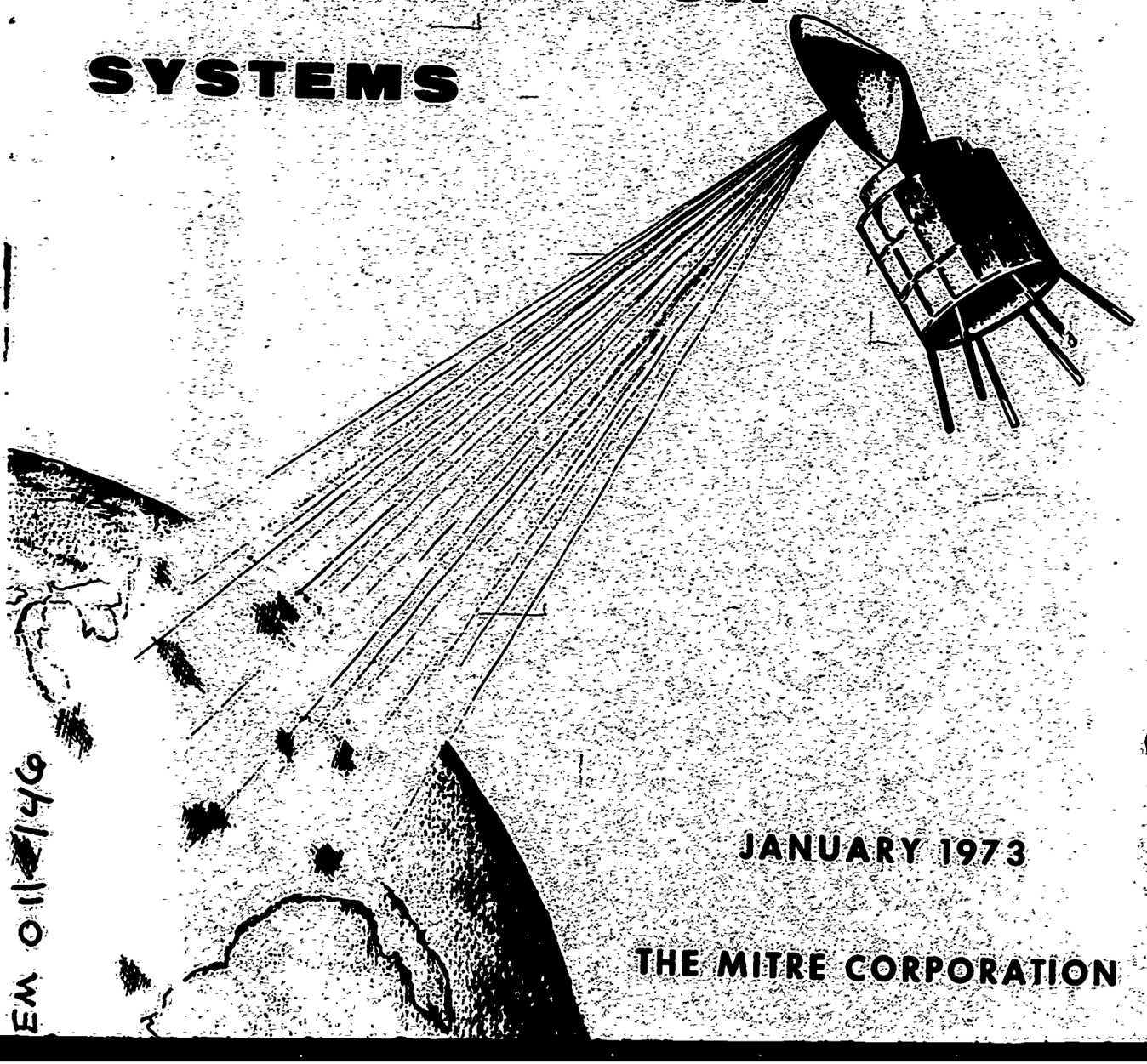
PRELIMINARY THOUGHTS ON NETTED CABLE COMMUNICATION SYSTEMS



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THE MITRE CORPORATION

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ABSTRACT

The MITRE Corporation has been experimenting, in Reston, Virginia, with a variety of interactive, wideband cable communication services, that could be provided through the use of a central, high-speed computer, and a number of modified, commercial home TV sets. Such services as computer-aided-instructions, time-shared home computers, remote shopping, reservation services, opinion polling, alarm monitoring, automatic meter reading and other utility services, cashless financial transactions, electronic mail delivery, various types of social services, Pay TV, and local community programming have already been demonstrated by MITRE and others. The technology and economics involved in providing such services for homes, schools, businesses and government agencies, particularly in urban areas, has been presented in a recent MITRE Report, entitled "Urban Cable Systems," that has generated widespread interest in such capabilities. However, the netting of local cable communication systems on a national or international basis via satellites or other means, appears to be critical in making many of these new services viable. Since these possibilities may be destined to have a significant impact on the structure of our society, it is worthwhile to consider some of the options in detail.

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INTRODUCTION

A recent MITRE Report[1] discusses various categories of communication systems that can be provided to a community through the use of local, wideband cable nets. These categories include:

- Conventional Community Antenna Television (i.e., CATV) Systems
- Pay-TV Systems
- Subscriber Response Systems
- Electronic Information Handling Systems
- Two-Way, Audio/Video Systems

Each of these will be briefly described in this paper, in terms of the types of services offered by each, the facilities required to provide these services, and any special characteristics that are desired for satisfactory operation of each system. In particular, the requirements for any private communication modes are discussed, as well as the desirability of internetting, via satellite communications or other means, different types of local cable communication services, the general need for compatible terminal designs that can supply all desired types of services, and the requirements for a set of universal technical standards for communication systems that would utilize satellites to intertie local wideband cable nets.

Conventional CATV Systems

The Conventional CATV Systems are designed primarily, to provide more and better quality off-the-air TV broadcast signals. In addition such systems provide "mechanical signals" (i.e., time, weather, news ticker, stock ticker, etc.) and, in systems with more than 3500 subscribers, local programming of community events is required by the Federal Communications Commission (FCC). The FCC has recently required that all new systems provide three free channels for public access, education and local government programming.

The number of such conventional systems has grown from a total of 70 in 1952, with 1400 subscribers, to over 2500 in 1971, with over 5 million subscribers. Such systems have been found to be particularly viable in rural areas and small towns where the

[1] W. F. Mason, et al "Urban Cable Systems" M72-57, The MITRE Corporation, 1972.

number of available off-the-air TV broadcast signals is small, or in urban areas where multipath signals and the shielding of signals by tall buildings is a problem.

Such Conventional CATV Systems require a "headend" consisting of a set of tower-mounted antennas, located on high terrain, that are used to pick local and distant signals off the air. Microwave or other types of landline links are currently used to transport distant signals from antennas located in neighboring regions to the headend. A typical headend also contains equipment for processing the TV signals that are picked up (i.e., filtering, shifting carrier frequencies, multiplexing and amplifying signals, and transmitting them over the cable net). The headend also usually contains an associated TV studio for generating mechanical signals and local programming. This studio might contain TV cameras, editing and special effects equipments, videotape recorders and associated equipment.

The distribution network for Conventional CATV Systems consists of trunking cable, about 1 or 2 inches in diameter, and smaller feeder cables for neighborhood distribution. Each subscriber has a tap on a feeder cable and a dropline into the home or other terminal location. Many of the more modern systems carry more than 12 TV signals and require either two cables with an "A/B switch" at the receiver, or a set-top converter that selectively shifts all cable signals to a single frequency that can be shown on one receiver channel of the home TV set.

Since Conventional CATV Systems, generally, telecast the same TV signals to all system subscribers, one-way amplifiers are used throughout the cable net, and no private transmission modes are required.

Under present FCC regulations, the number, sources, and types of distant off-the-air signals that can be imported in the larger TV markets is limited. Under these circumstances, the main requirements for satellite internetting of Conventional CATV Systems will probably be for importation of local and special-interest programming (i.e., cultural events, sports programs, etc.) generated by other cable systems, and for importation of programming of special networks designed to serve the cable system industry.

Pay TV Systems

Pay TV Systems are designed to carry special TV programs such as first-run movies, special sports events, and cultural events such as symphony, opera, theatre, ballet, etc., for which the cable subscribers are expected to pay a premium fee. Such cable programs

will, generally, be cablecast on exclusive channels to large audiences. Special programs for doctors, lawyers, scientists, chess players, or other groups with special interests could also be provided in the Pay TV mode.

At present, a number of types of Pay TV Systems are being developed for use on cable. Many of these are, currently, being used mainly in hotels and motels in closed circuit TV modes of operation. Some of these types of systems are summarized in Table I.

Most of the current designs for Pay TV Systems can be used with one-way cable transmission, and are, therefore, compatible with Conventional CATV Systems. However, additional equipments are needed, at the headend, to scramble, code or shift the frequencies of the signals transmitted, and, at the terminal locations, to descramble, decode or deshift these signals so that they can be viewed by subscribers willing to pay the additional fees required.

It is expected that many of these Pay TV programs will, eventually, be distributed to cable systems on a nationwide basis and will, therefore, be prime candidates for satellite transmissions.

Subscriber Response Systems

Subscriber Response Systems are defined, here, as those that transmit data both in an upstream direction when generated by subscriber terminals and in a downstream direction when generated by a computer at the system headend.

The kinds of services provided by Subscriber Response Systems include various types of interactive entertainment and educational programs, where the audience responds to questions asked by performers or teachers on camera, as well as various types of preference polling and marketing surveys provided on either a manual or automatic basis. Other types of Subscriber-Response services include shopping and reservation services, alarm communications (i.e., fire alarm, burglar alarm, gas leak alarms, flood alarms, etc.) and various types of utility and maintenance services, including meter reading, selective load control, load monitoring, preventive maintenance tests for electronic equipments, etc.

The additional equipment required to provide these services includes a computer, at the headend, to sequentially transmit addressed queries, in the form of data signals, to the subscriber terminals. This is done on a time-shared basis using a single downstream channel of the cable net. Each household is provided with a data terminal, examples of which are shown in Figures 1 and 2. The data terminal for each household contains a

TABLE I
SUMMARY OF PAY TV SYSTEM DEVELOPMENTS

NAME OF SYSTEM	TYPE OF CABLE SYSTEM REQUIRED	METHOD OF EXCLUDING NON-PAYING VIEWERS	METHOD OF ACCOUNTING FOR SERVICE CHARGES	ESTIMATED INCREMENTAL CAPITAL COSTS
BTVision	One-Way	Video sync pulse and audio signal sent on separate channels, and recombined with video signal at receiver	Identification code for each program recorded on audio cassette and returned, periodically, by mail	$100 per Terminal
EnDeCODE	One-Way	Similar to BTVision	Fixed rate for service	$40 per Terminal
Computer Television	Two-Way	Viewer transmits program requests to central control station via cable. Central control remotely sets varactor tuners in subscriber terminals	Central control records programs requested	$600 per Terminal
K'Son	One-Way	Viewer telephones requests to central control station. Central control remotely sets program selector units to desired channel	Central control records programs requested	$100 per Terminal
Optical Systems	One-Way	Encoded signals sent from headend which are decoded at receiver by use of decoder cards or plug-in decoder cartridges	Viewer buys decoder cards or plug-in decoder cartridges for series of programs	$35 per Terminal
Phonevision and Theatre VisioN	One-Way	Encoded signals sent from headend which are decoded at receiver by subscriber ticket and decoder control unit	Viewer buys decoder tickets for individual programs	Not specified

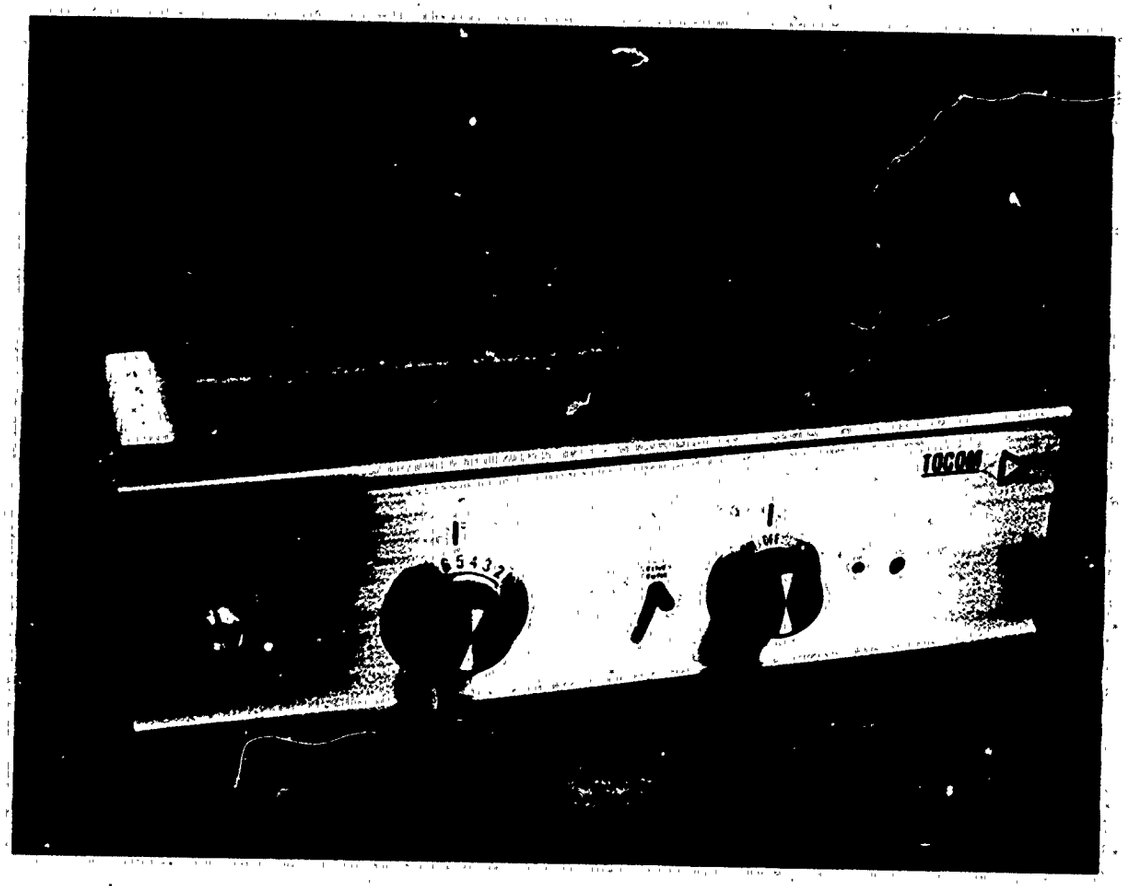

FIGURE 1
TOCOM TERMINAL FOR SUBSCRIBER RESPONSE SYSTEM

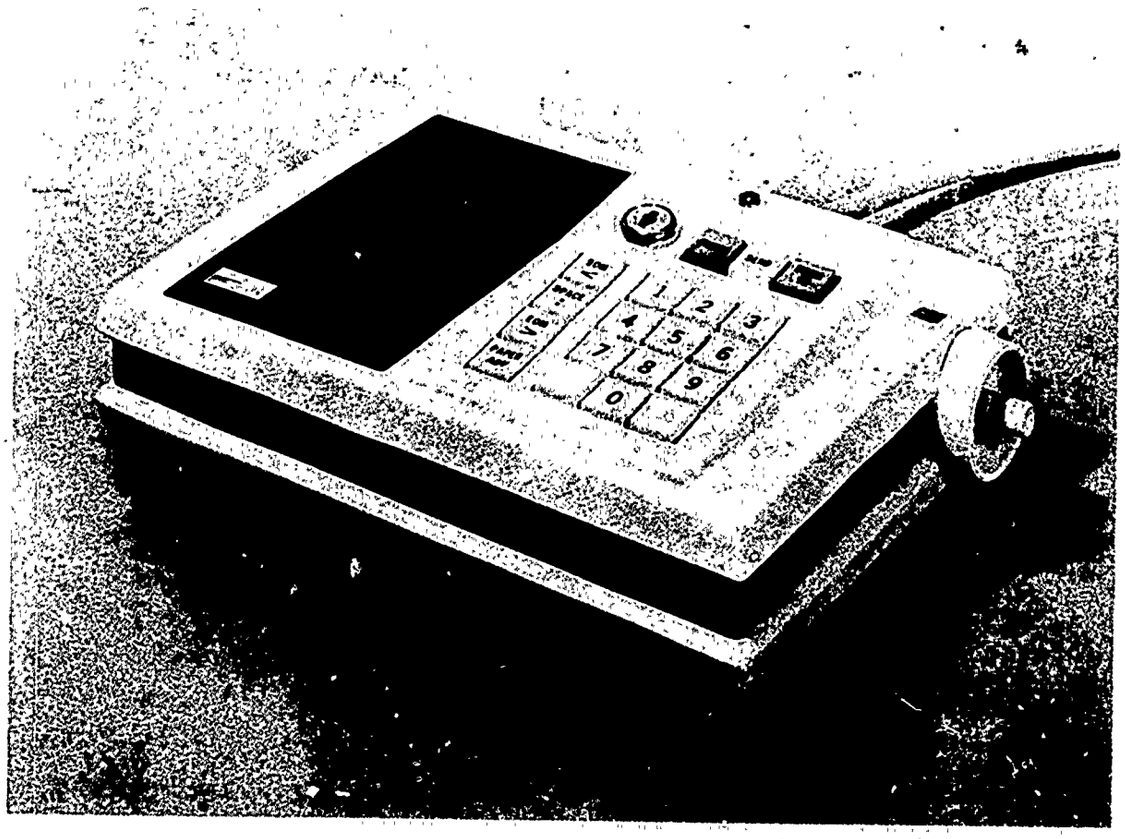

FIGURE 2
THETA-COM TERMINAL FOR SUBSCRIBER RESPONSE SYSTEM

unique address which is continuously matched against the stream of data signals sent from the computer. When a match occurs the terminal responds by transmitting, back upstream to the headend computer on another time-shared channel, the data information that has been temporarily stored at that household terminal. This information includes data generated by the viewer using the buttons on the subscriber response terminals (see Figures 1 and 2), as well as data provided by the sensors, alarms, meters, and other auxiliary devices located in the household. The headend computer receives, processes, and stores the data from each household and takes appropriate actions. For instance, viewer responses can be immediately tabulated and displayed to the viewer audience, fire alarms can be relayed to the appropriate fire stations, meter reading information can be stored and monthly bills issued, etc.

Another type of system in this category (i.e., the MITRE Digital Cable Communication System) can be used, with the addition of a teletype, facsimile or other suitable terminal device, to provide hardcopy communications between different subscribers in a system. Such a system can also be used for delivering mail, bank account information, computer-stored information and other types of information that are requested in a hardcopy format. The mode of operation of the MITRE Digital Cable Communication System is somewhat different than the type of system described above, in that it dynamically allocates available system capacity, and provides each subscriber only with that capacity he needs for the type of terminal and the rate of information transmission that he is using at any specific time.

Some of the services provided by Subscriber Response Systems (e.g., opinion polling, shopping and reservation services, and hard copy communications between subscribers, and to subscribers from computers and other data sources) will require privacy of the information transmitted. Some such services (e.g., reservation services, long-distance communications between subscribers, etc.) will also require internetting of local cable nets through the use of satellite communications, or other means.

Electronic Information Handling Systems

Electronic Information Handling Systems are defined, here, as those that transmit data, generated by viewers, in the upstream direction, and audio/video information, generated by computers or other means, in the downstream direction of a cable system net.

The types of services provided by Electronic Information Handling Systems include computer-aided instructions, time-shared, home computer services, cashless financial transactions, electronic mail delivery, library information, shopping services, reservation services, interactive entertainment, computer generated games, and various types of social services (e.g., vocational training, information on job and housing availability, etc.).

During the past eighteen months, the MITRE Corporation has been demonstrating a large variety of these types of interactive, two-way cable communication services, using a high-speed computer located at the MITRE facilities in McLean, Virginia (see Figure 3), that is interconnected to a channel of the Reston Transmission Company's cable system network in Reston, Virginia. As indicated in Figure 4, the downstream, audio-video interconnection, from the MITRE computer (see Figure 5) to the Reston cable headend, is via a microwave link. The downstream audio-video signal is carried on Channel 13 of the A cable, in the Reston system, to all subscriber's homes connected to the system. A typical interactive two-way terminal in a subscriber's home is shown in Figure 6.

In the initial experiments, the upstream data signals, consisting of viewer's responses to computer generated questions, or requests to the computer for specific pieces of information stored by the computer, were inserted by Touchtone ® telephone (see Figure 4), and were carried, via Chesapeake and Potomac telephone lines, to the MITRE computer facility in McLean.

Alternatively, a full keyboard, instead of the Touchtone ® telephone, can be used to insert upstream data signals at a viewer's terminal. Although the keyboard selected for this purpose is a standard type, the key layout has been selected to simplify operations. The center of the keyboard is similar to that of a standard IBM Selectric ® typewriter. The keys on the left provide cursor and editing control, while the keys on the right provide viewer control options.

Recent modifications of the Reston cable system provide two-way transmission on the cable network, which permits upstream data signals to be sent from viewers' homes, via a cable channel, to the cable system headend and, thence, from the headend to the MITRE computer facility, via the microwave link.

MITRE's demonstration system, which is known as the Time-Shared, Interactive Computer-Controlled Information Television (TICCIT) system, is composed mostly of

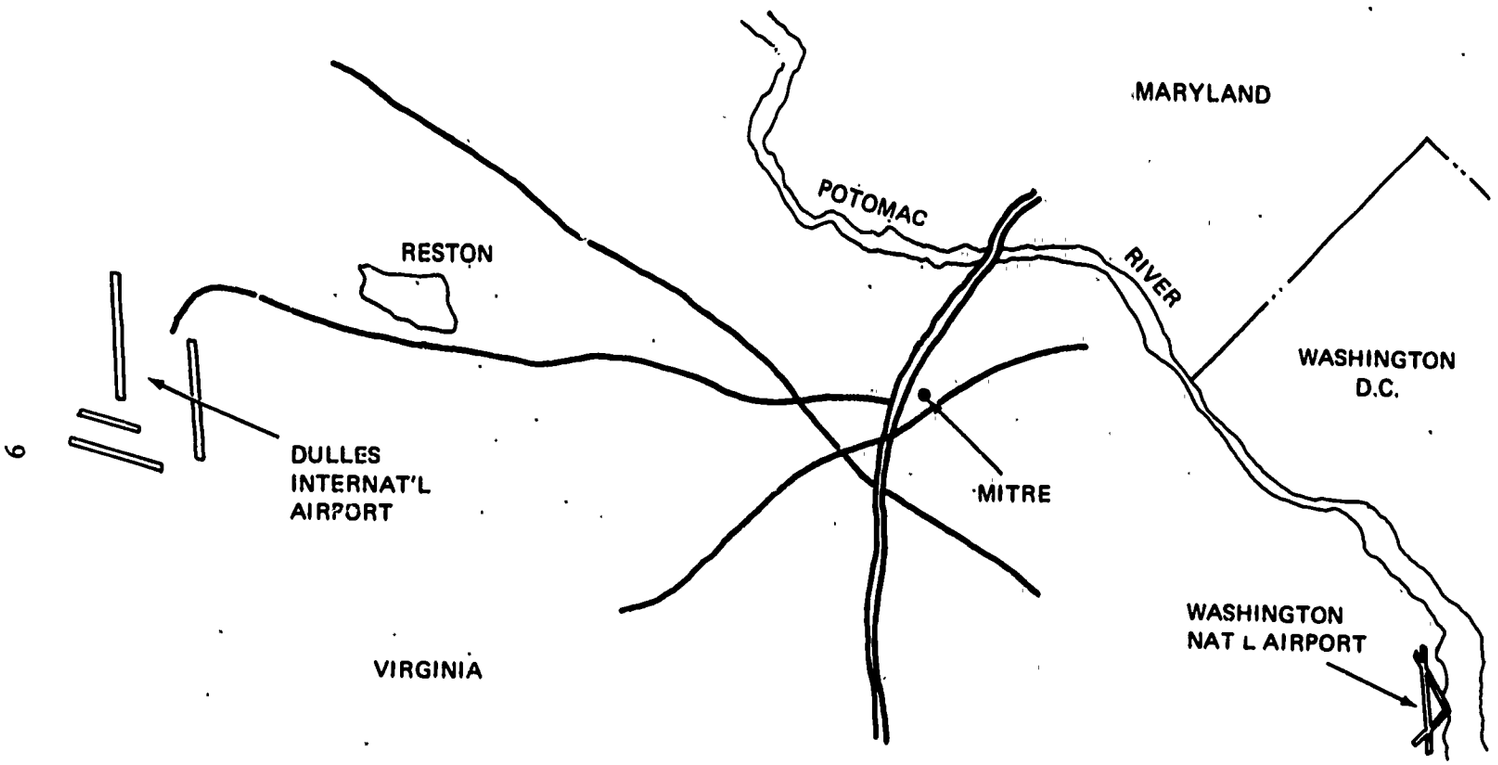

FIGURE 3
LOCATION OF MITRE/RESTON TICCIT DEMONSTRATION

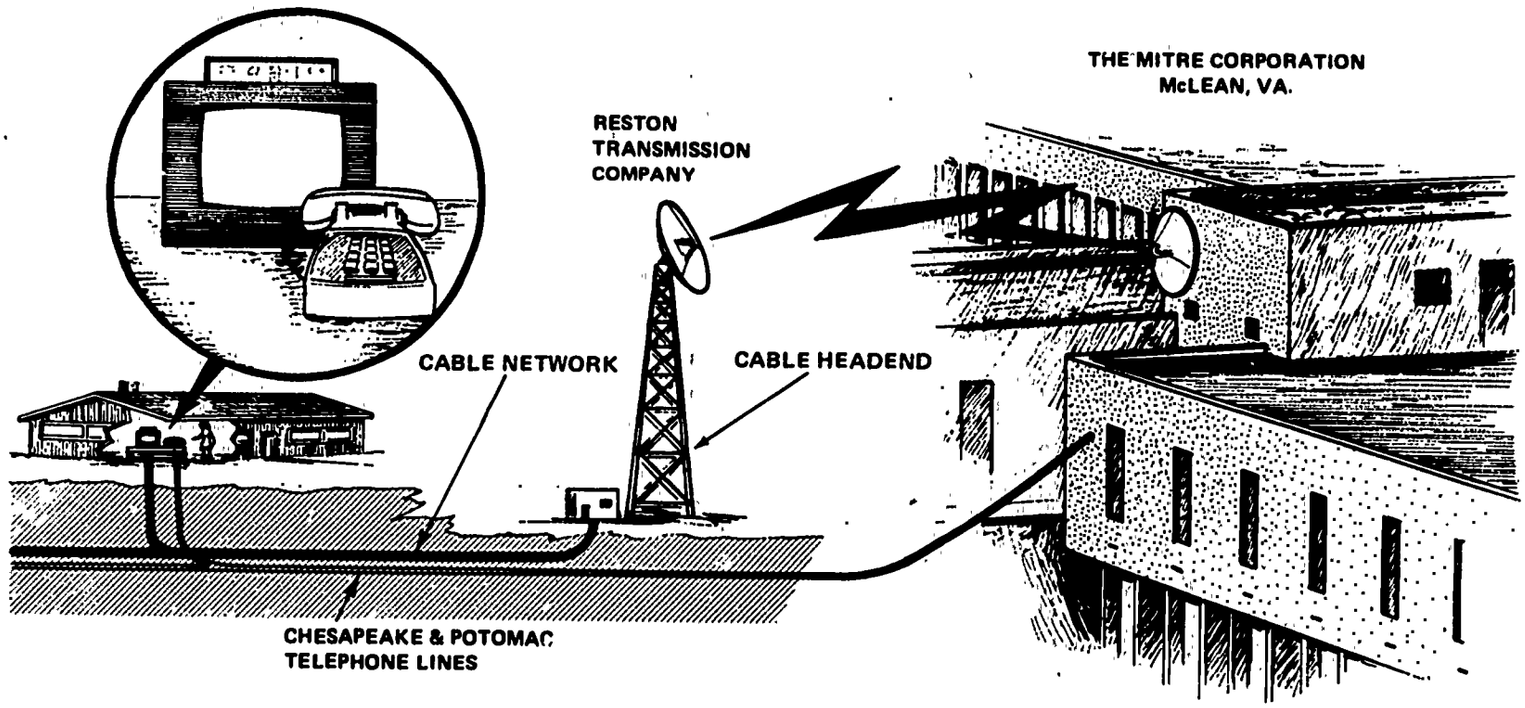

FIGURE 4
MITRE/RESTON INTERACTIVE, TWO-WAY CABLE COMMUNICATION SYSTEM

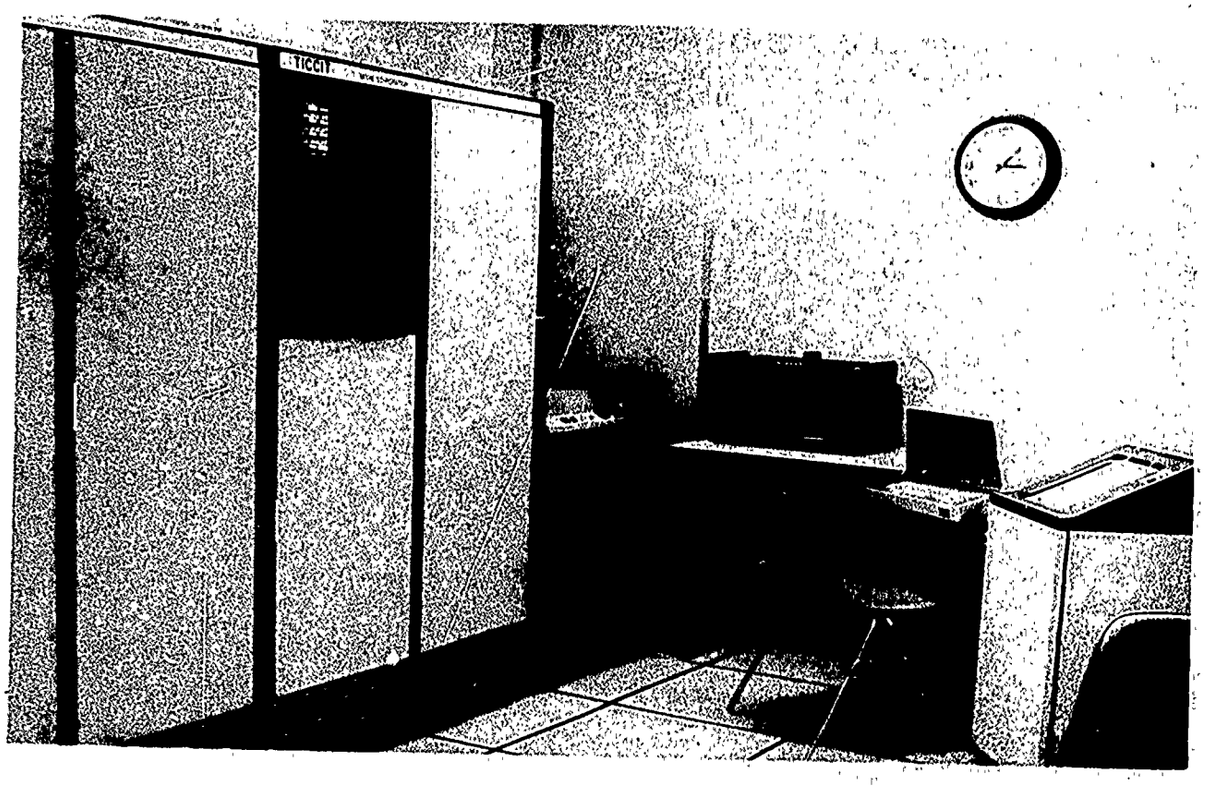

FIGURE 5
MITRE COMPUTER FACILITY IN MCLEAN, VIRGINIA

FIGURE 6
TYPICAL INTERACTIVE, TWO-WAY TERMINAL IN SUBSCRIBER'S HOME IN RESTON, VIRGINIA

off-the-shelf hardware, with a few specially designed subsystems added. It uses standard, commercial color TV receivers for display at the viewer's terminal. In addition, it provides, either at each home terminal or at local distribution centers of the cable system, a capability to freeze, or stop, individual video TV frames, using either a video tape recorder, an image storage tube, a video disc, or a solid-state memory unit. This allows each pair of minicomputers, and their associated disc data storage units, to support over 100 viewers' terminals, simultaneously.

The viewer's terminal provides a pleasant and efficient interface between the viewer and the computer. The color TV displays, which are under computer control, consist of both alphanumerics and line graphics in seven colors, as well as full color movies. Up to 17 lines, consisting of 41 characters each, may be displayed in each TV frame sent from the computer. The character set is completely programmable, with up to 512 distinct characters being definable on any given frame.

Graphic displays may be constructed from straight-line segments drawn on a grid of 200 elements in the vertical direction, by 256 elements in the horizontal direction. The color of each character and line-segment may be specified, individually. Segments of full-color movies can be added to provide variety in the computer/viewer interaction, and to give the computer courseware writer an effective tool in dramatizing difficult concepts. To further augment the visual display, pre-recorded audio messages can be sent under computer control.

Two-Way Audio/Video Systems

The Two-Way Audio/Video Systems are characterized by their capability to transmit audio and/or video signals, in both upstream and downstream directions. These systems are, in effect, extended Closed Circuit Television (CCTV) systems that use cable to increase the useable distance between terminals in the net.

Two-Way Audio/Video Systems can be used for interconnection of business offices and information centers, such as classrooms, libraries, health centers, social service centers, and the like, or for remote origination of special programming for a telecasting net. The use of this type of system in the teaching and the caring for disabled children, shut-ins, and others, has been demonstrated on the Overland, Kansas, Cable System.

Two-Way Audio/Video Systems require that television cameras be provided at each terminal where a video signal is originated. Such systems, generally, use continuous

video signals, although it is possible to operate them in a stopped-video mode, if frame-stopper terminals and a central processing unit are available. Associated voice signals are usually provided with the video signals. Transmission circuits for these systems can be set up on a dedicated basis between a fixed set of terminals, or some means of switching can be provided in order to time-share circuits in the net.

Because of the relatively high cost of both the video switching and the television cameras required, it is not anticipated that there will be a heavy demand for this particular type of system, except between remote locations that are not accessible by other means. Two-way audio/video communications, via satellites, are being demonstrated in the NASA/ATS Program for inter-campus exchange of library resources and curriculum materials, as well as for social and educational services, and interchange of medical information, between metropolitan centers and remote villages.

Economics of Cable Communication Systems

As indicated in Reference 1, a MITRE Economic Model has been developed and used to estimate the economic viability of alternative types of systems. Figure 7 is a block diagram of the procedures used to conduct these economic analyses. Detailed data on capital expenditures, and operating and maintenance costs form one set of inputs.

Annual revenues are assumed to be derived from a combination of subscriber's fees, advertising, and fees on leased channels and special point-to-point nets. The percentage of households that can be expected to subscribe to various types of services, that could be provided by the different categories of systems described above.

The computer program estimates the total annual costs and revenues for the system, and from these develops a number of outputs from which the economic viability of the system can be estimated. These outputs include pro forma summaries of capital costs, operating statement, cash flow statement and balance statement, as well as various types of break-even points, estimates of the equity value of the system, and rates of return on equity, investment, etc.

General Observations on System Requirements

Based on studies and analyses of cable systems that have been completed to date, the following general observations on requirements for cable communication systems are made:

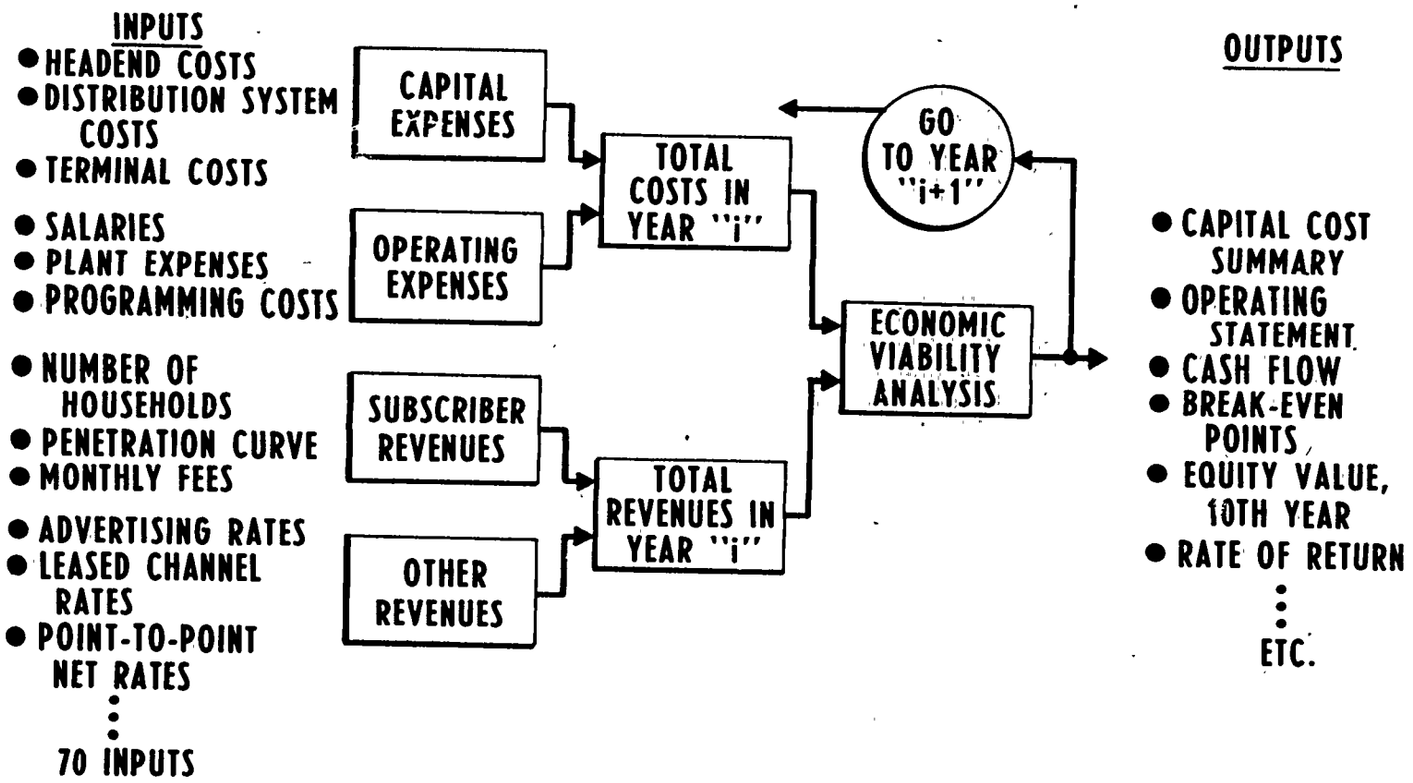

FIGURE 7
PROCEDURES USED IN ECONOMIC VIABILITY ANALYSES

- Most cable systems in smaller TV markets can be expected to achieve economic viability if they supply only conventional CATV signals (i.e., local and imported off-the-air signals; public access, education and minicipal channels; mechanical originations; and some local programming). For these conventional CATV systems, the types of programming that might require some internetting, via satellite communications, are those for one-way educational services, or various types of one-way social services on municipal channels (e.g., medical services, legal services, etc.)

- Many cable systems operating in intermediate TV markets will probably require Pay TV, in addition to conventional CATV programming, in order to achieve economic viability. Many of these Pay-TV programs, consisting of new movies, national sports events and various types of cultural events, may be distributed on a national basis, using satellite communications.

- Many cable systems in the largest TV markets will probably require the incorporation of various types of two-way systems and services, in addition to conventional CATV and Pay TV, in order to achieve economic viability. Such services that might be expected to be supplied on a nationwide basis, via two-way satellite communications, include electronic mail delivery, reservation services, polling services and computer-aided instructions. Various types of interactive entertainment programs, shopping services and library services, as well as load monitoring and control for various utilities, may also require nationwide links via two-way communication satellites.

In summary, it is expected that interconnections of local cable systems will probably be required mainly in the intermediate and largest TV markets, for national distribution of Pay TV and some two-way services, and in the smaller TV markets for some one-way educational and social services.

Finally, it should be noted that the initiation of satellite internetting of local cable communications systems will necessarily create a demand for compatible cable system designs and universal technical standards for those systems that are internetted.